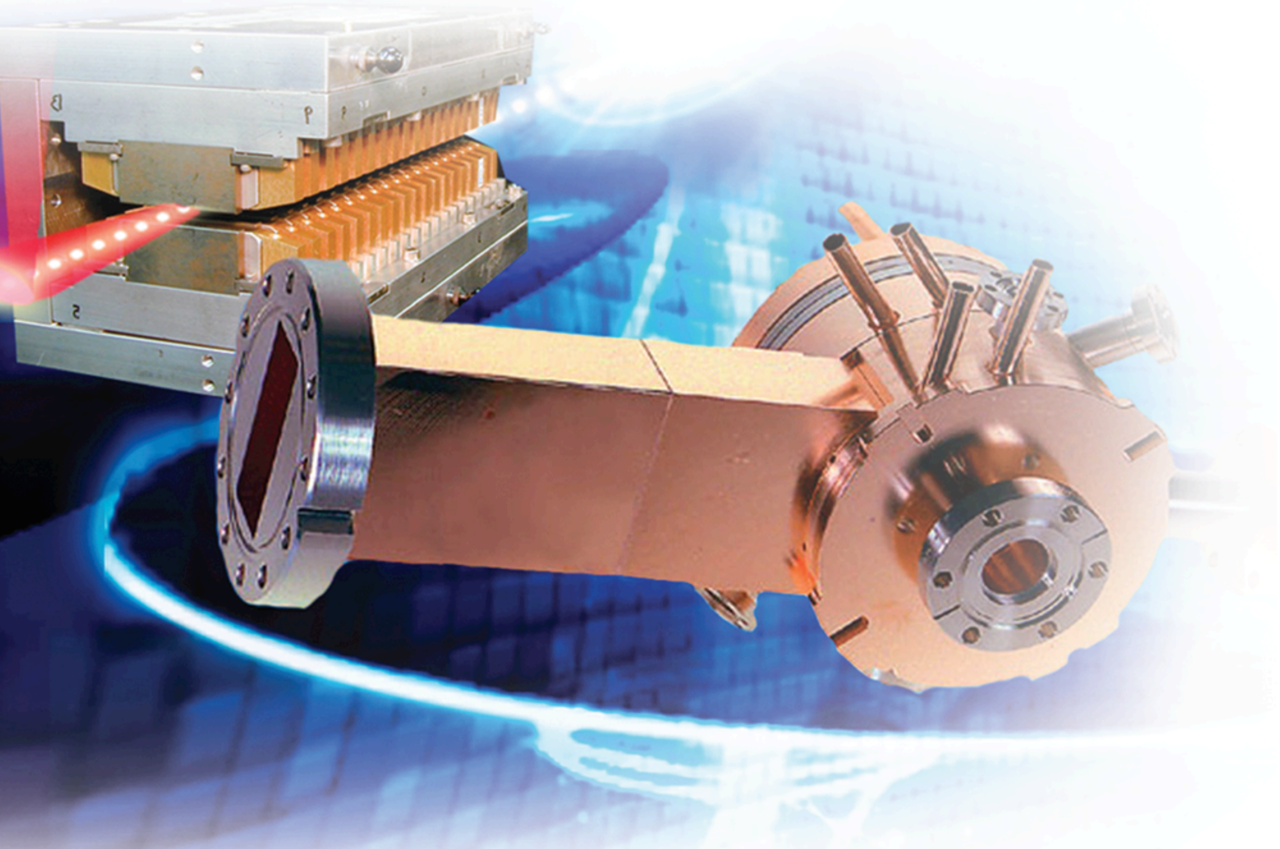


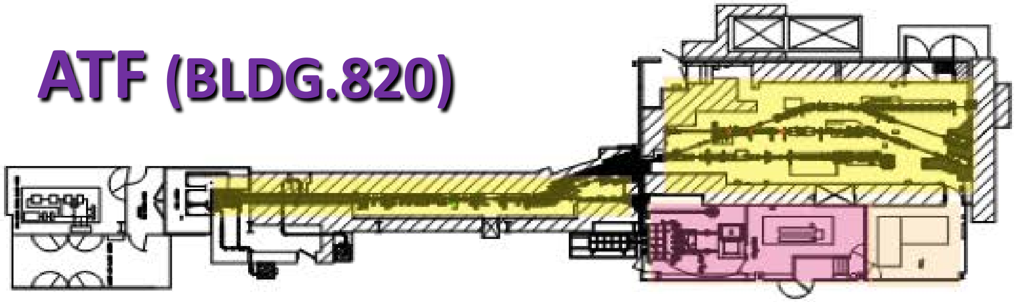
New ATF capabilities update

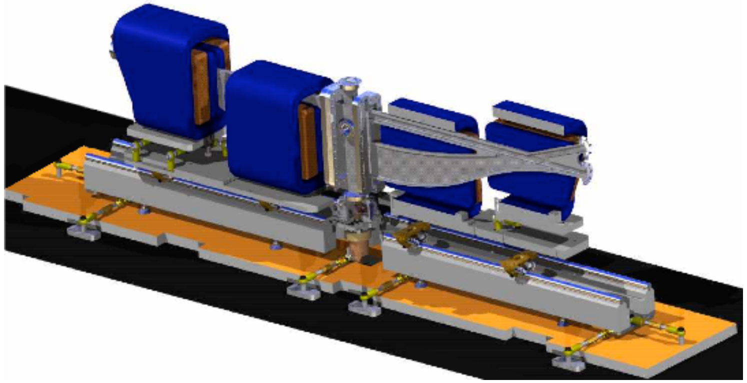
by Mikhail Fedurin,
BNL ATF

ATF main beam parameters

Parameter	Typical value / range	Best value
Energy	30-80 MeV	80 MeV
Charge	0.1 – 1 nC	3 nC
Repetition rate	1.5 Hz	10 Hz
Electron spot size on cathode	2.86 mm	0.2 – 4 mm
Bunch length	1-8 ps	100 fs with compression
Average bunch current	100 A	1.5 kA with compression
Emittance	1 – 3 mm mrad	0.8 mm mrad @ 0.5 nC

ATF (BLDG.820)

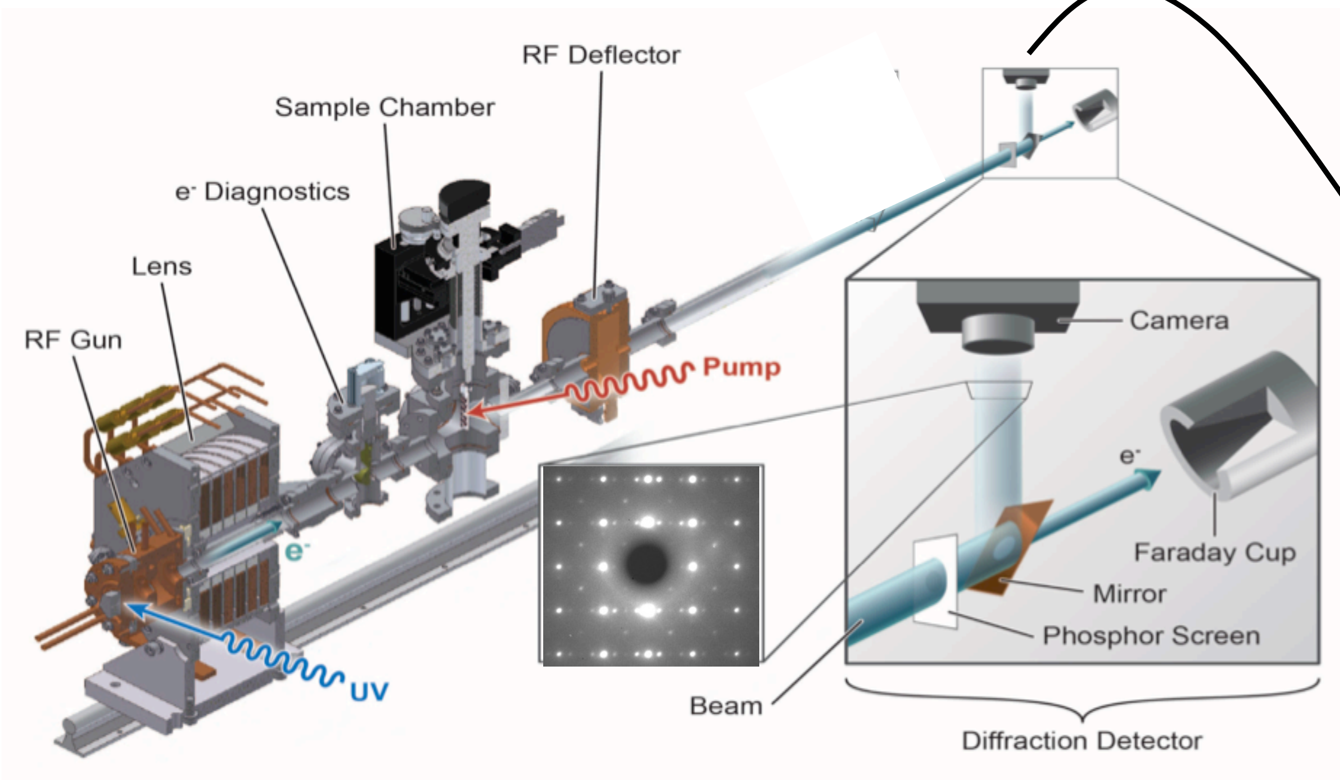




New ATF capabilities

- UED beamline
- X-band deflector cavity

Ultrafast Electron Diffraction beamline



Setting time delay
and integration time

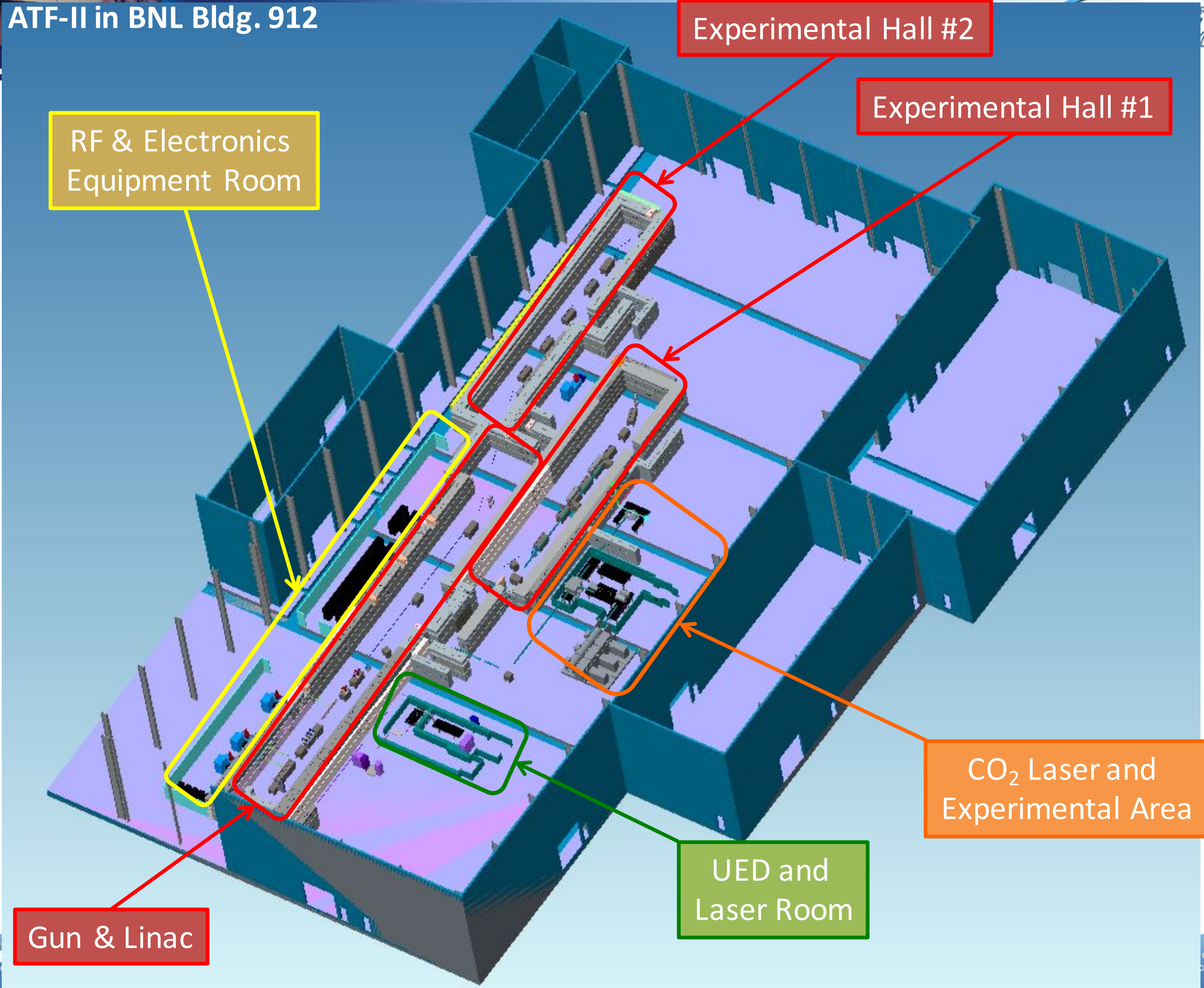
By courtesy of Junjie Li

UED at BNL milestones

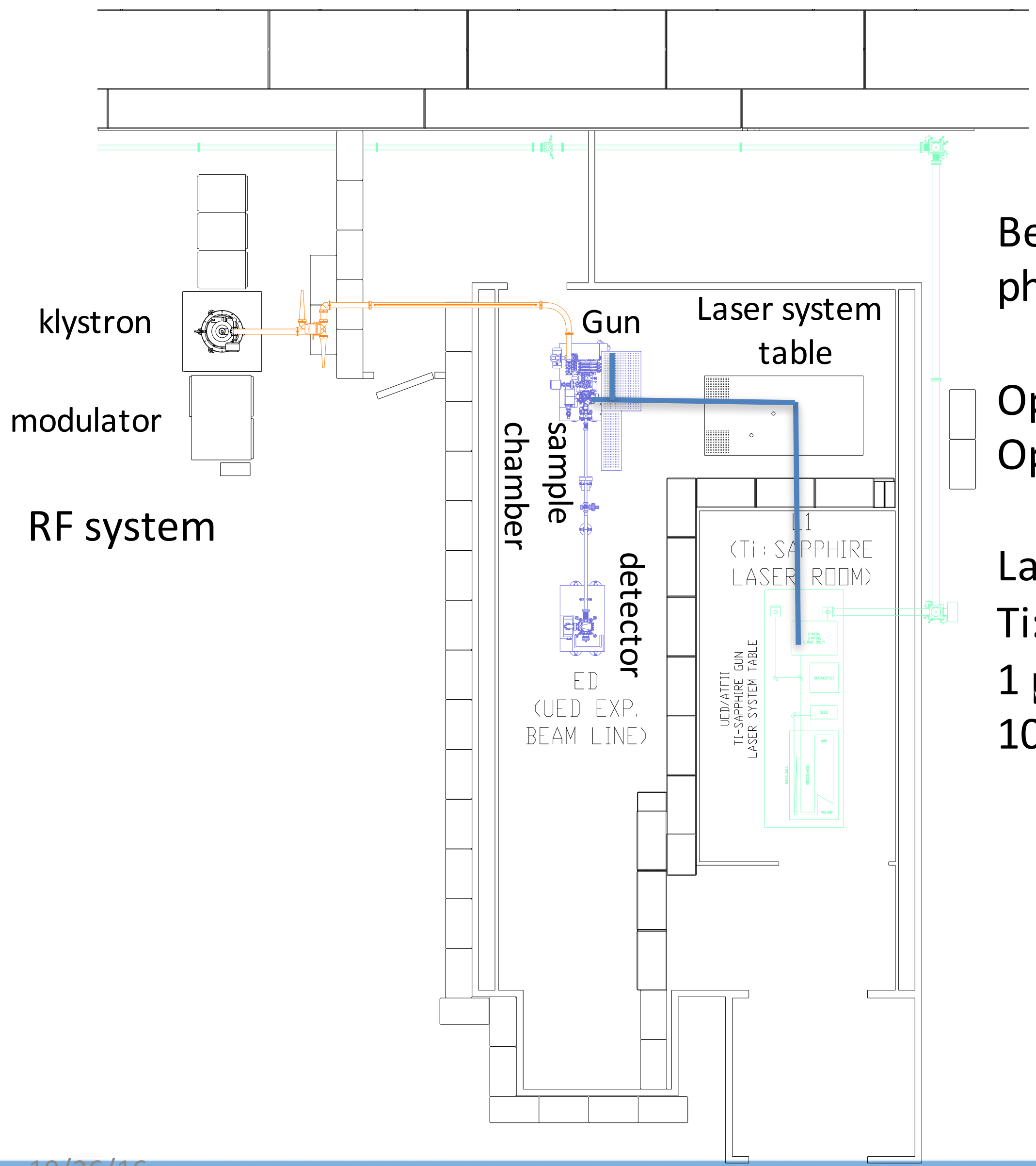
- UED beamline was in operation at BNL Source Development Laboratory since 2010

- In 2016 beamline moved to Bldg 912 and become part of ATF II facility complex

ATF-II in BNL Bldg. 912



UED beamline at Bldg 912



Beam source:
photocathode gun 1.6 cell 2,856 MHz

Operational beam energy: 2.8 MeV
Operational beam charge: 1 pC

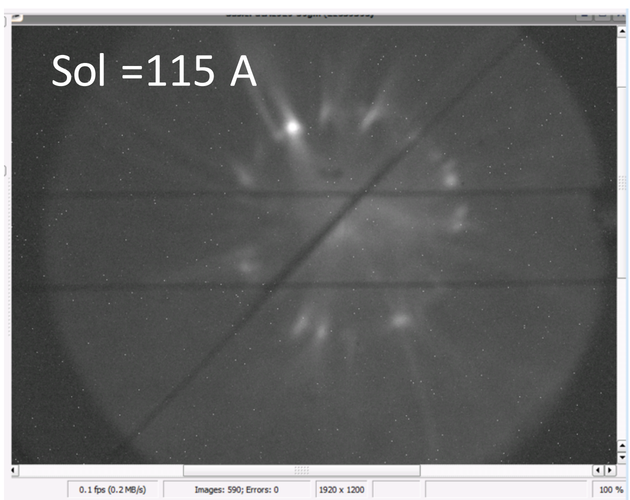
Laser:
Ti:Sapphire, pulsed 160 fs
1 μJ at photocathode
100 μJ at sample chamber

ATF UED milestones

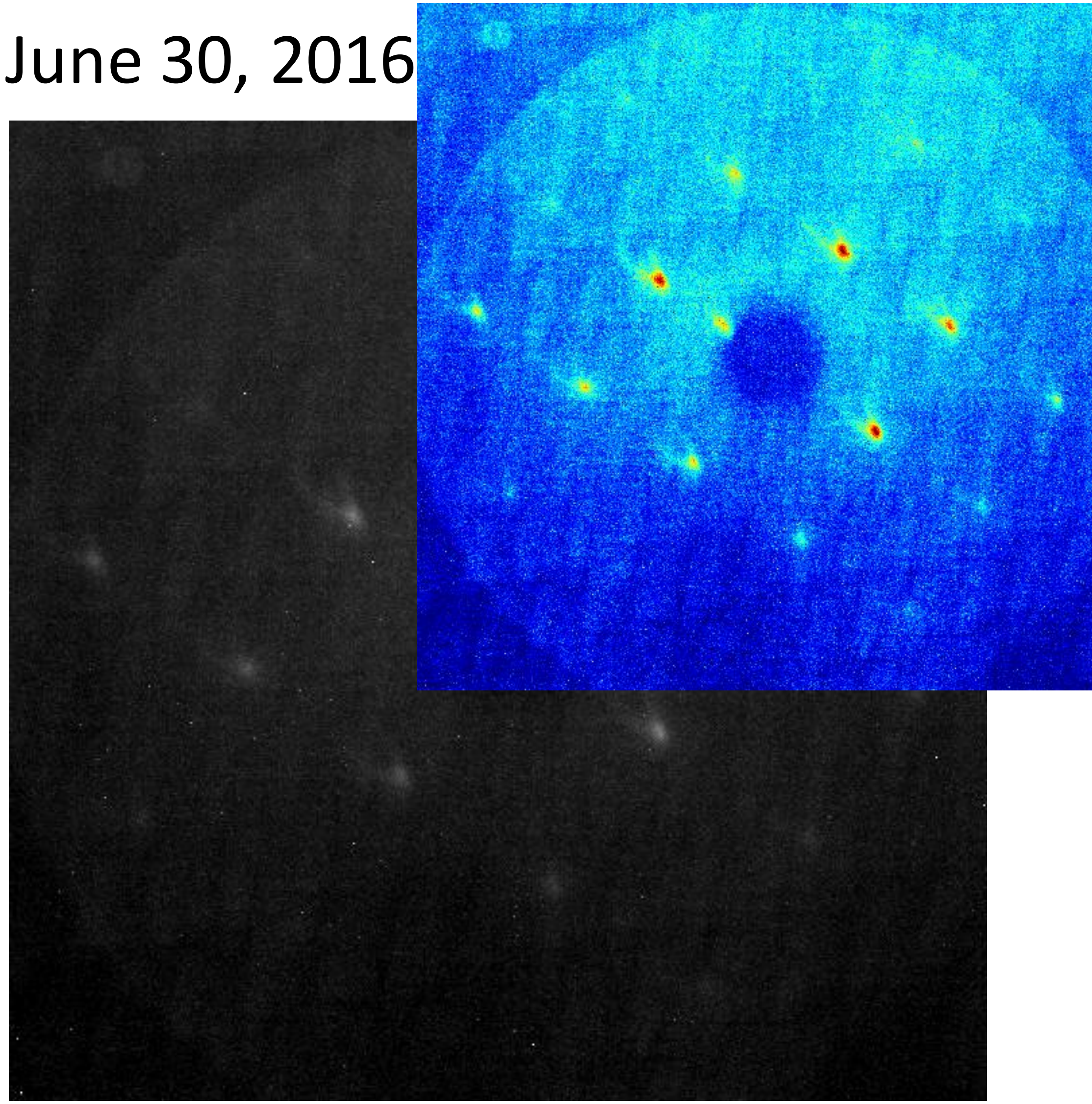
- December 2015: new layout was developed and approved
- January – February 2016: RF system and beamline was assembled in new location
- March 2016: RF system was commissioned, klystron and gun were conditioned to operational power, control system was ready for operation
- April 2016: UED readiness review; laser system commissioning
- May-June 2016: beamline commissioning, dark current and first beam observed at detector
- June 2016: first diffraction pattern at detector

UED commissioning

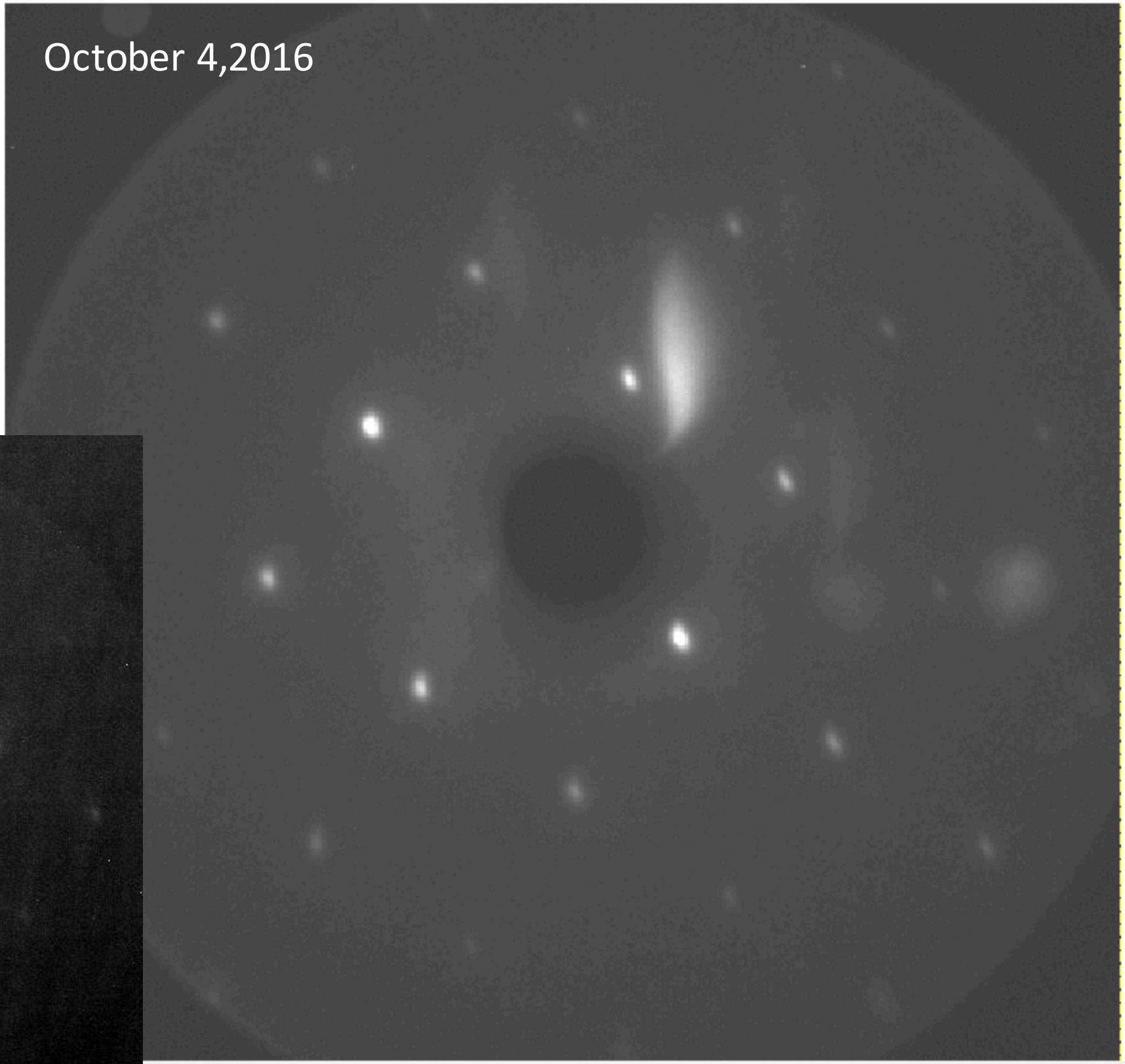
June 1, 2016: dark current observation on 1st BPM

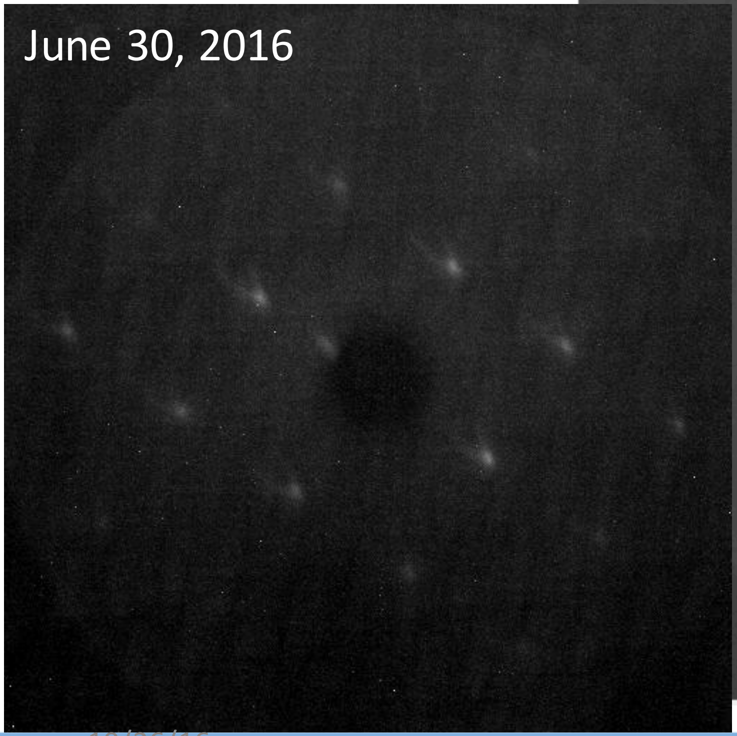


June 30, 2016



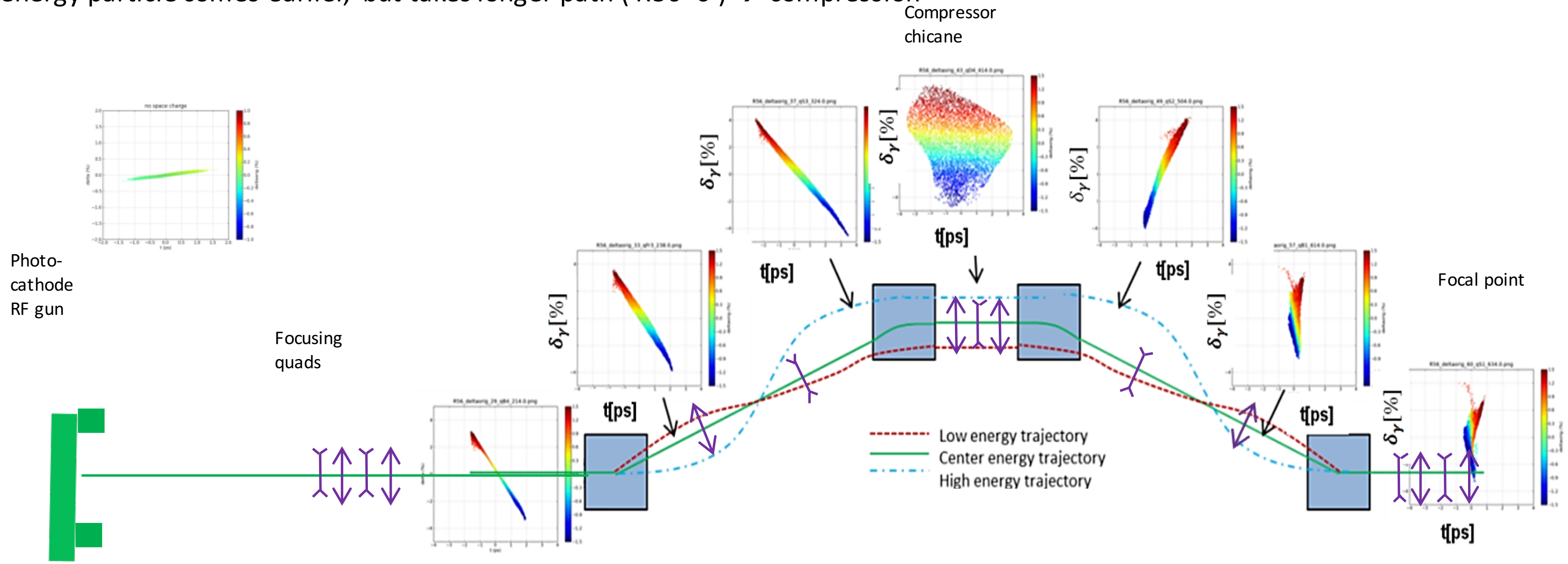
Most recent diffraction data





We developed a novel unconventional scheme to combine the correlated energy spread with the energy dependent path length to compress the electron bunch. The main point is to use space charge to generate the time-energy correlation.

Unconventional compressor developed in electron beam slicing :
Focusing→ space charge increase energy of electrons at head (chirped bunch)→
high energy particle comes earlier, but takes longer path (R56>0) → compression

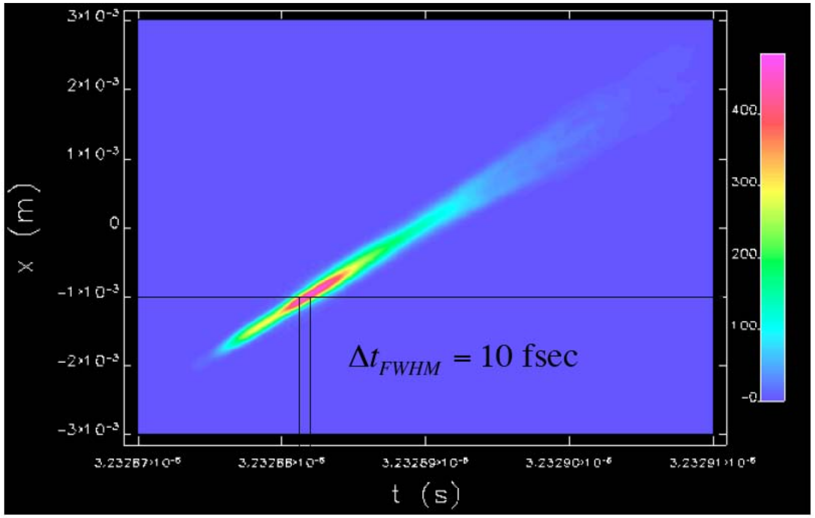


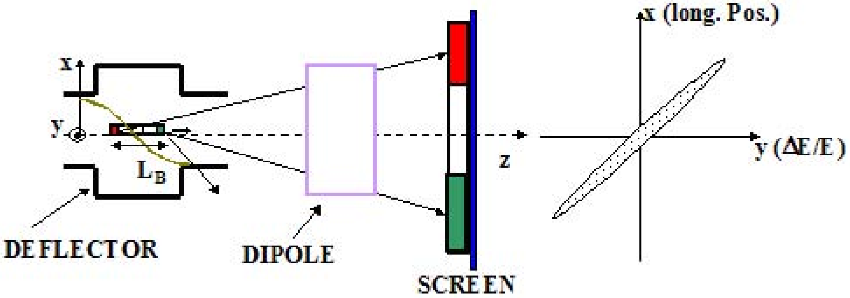
Approach: Use space charge effect to compress and focus electron bunches in space charge dominated domain

By courtesy of Li Hua Yu

Deflector cavity

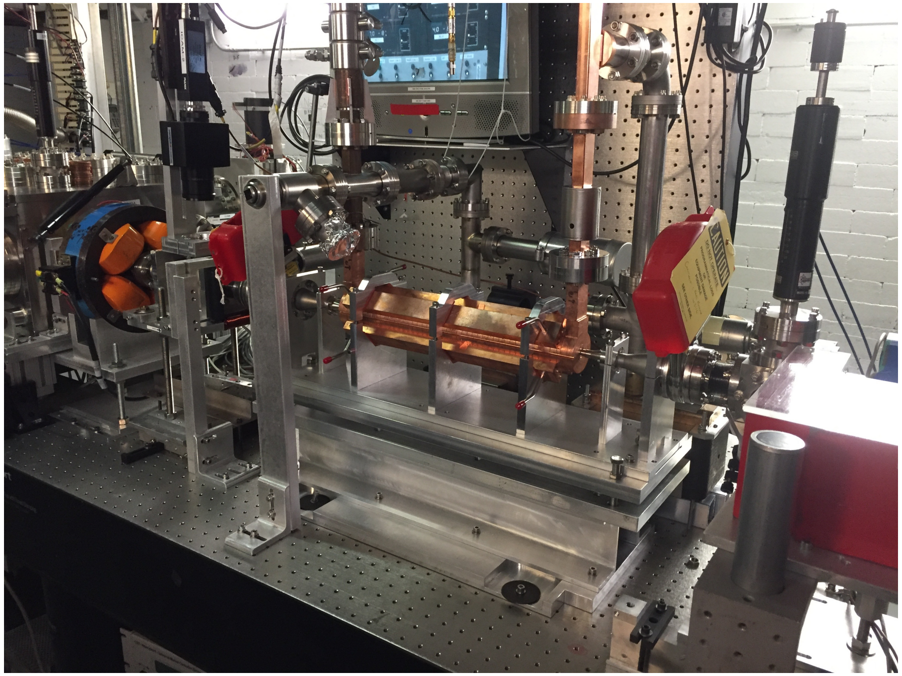
- X-band deflecting cavity offers unique longitudinal diagnostic capabilities
- Important features:
  - excellent temporal resolution
  - single-shot measurements
  - no pre-assumptions about the beam current profile
  - directly map the electron beam longitudinal phase-space
  - more reliable than other methods

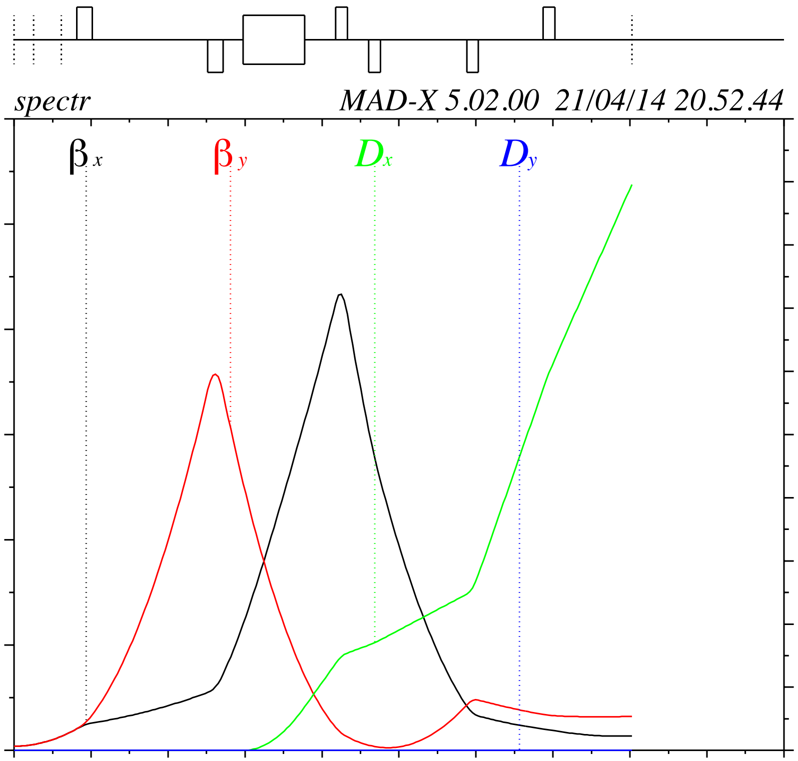




Deflector parameters and beam optics

Parameter	Value
Field amplitude, $\sqrt{E/P^{1/2}}$	8.48 kV/mW$^{1/2}$
Group velocity, v_g	0.0267c
Attenuation factor, α	0.66 m^{-1}
Cavity length, L_T	0.40 m
Number of cells, N	45



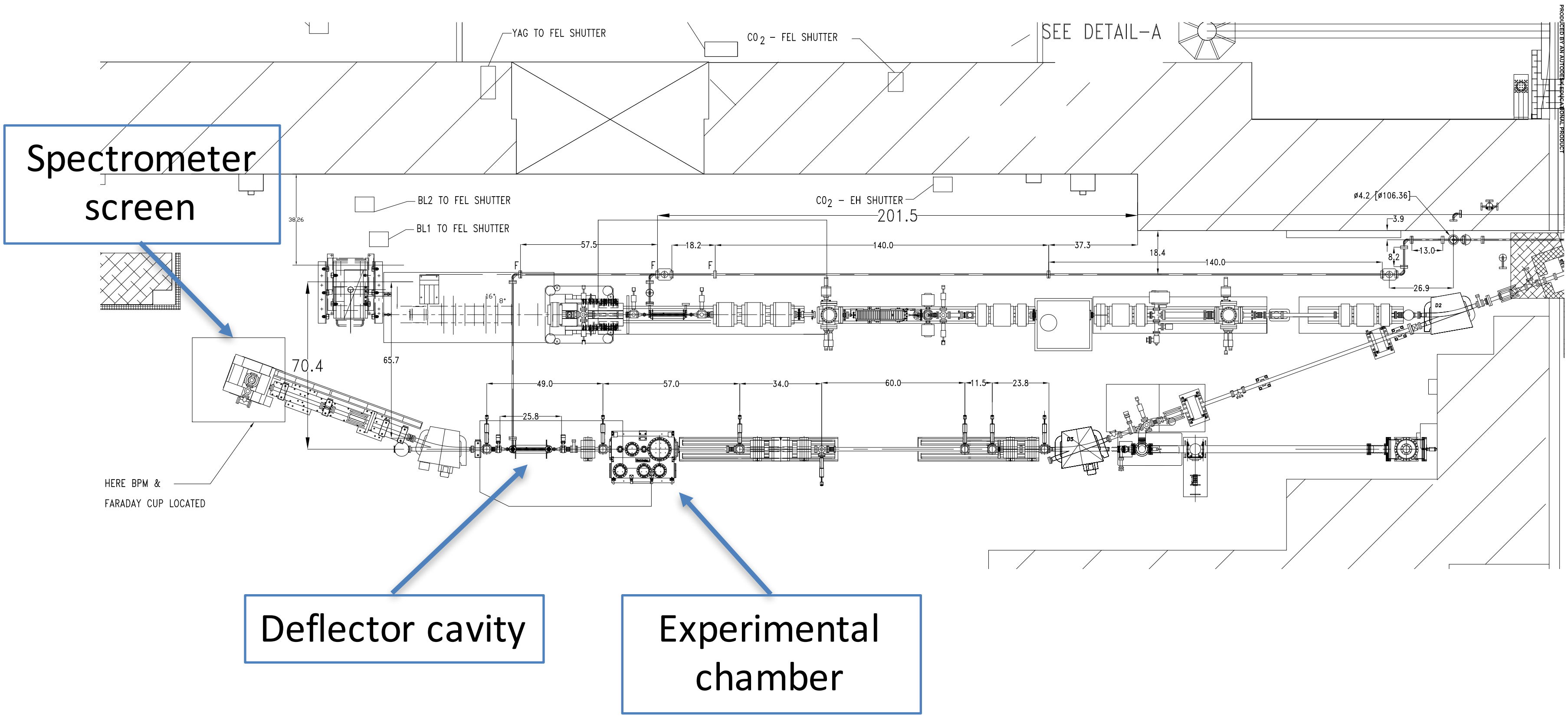


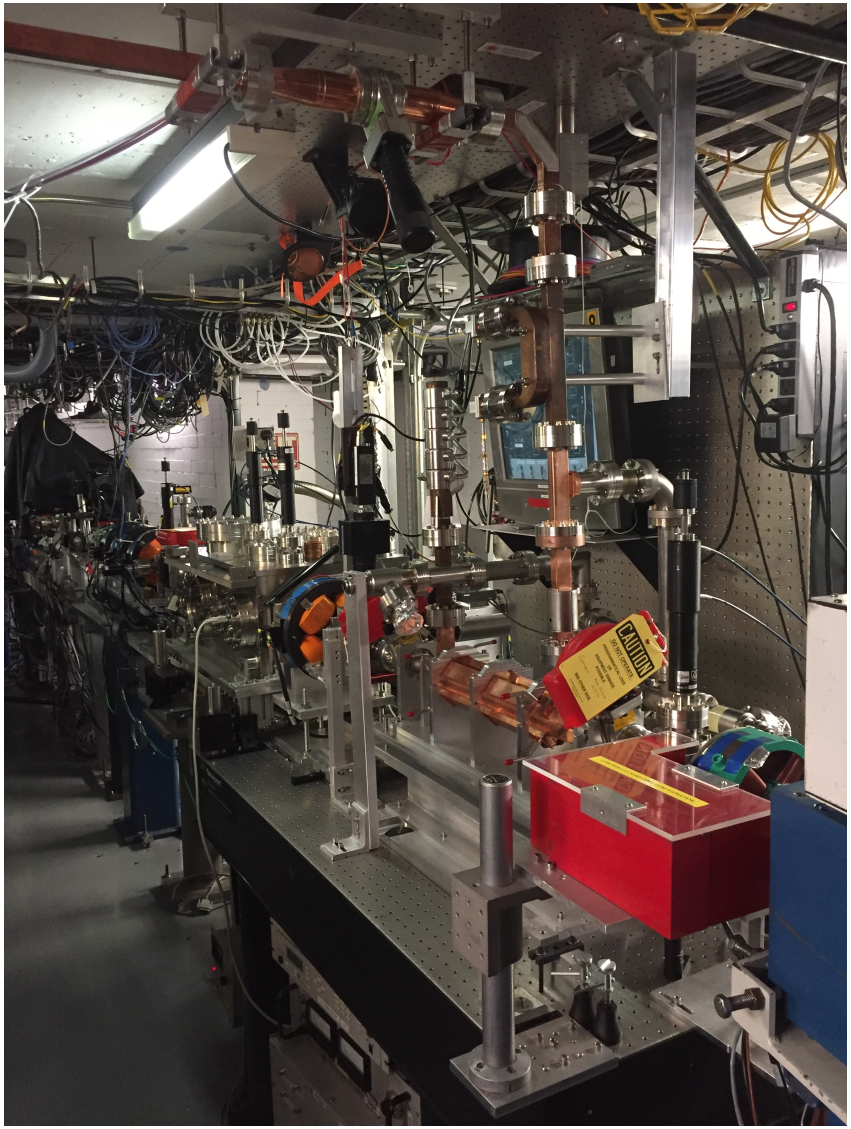
$$\Delta x_d = \omega_{RF} \Delta t \sqrt{\beta_d \beta_f} \left(\frac{eV_0}{E} \right) \sin\left(\Delta \psi_\beta \right)$$

Deflector conditioning milestones

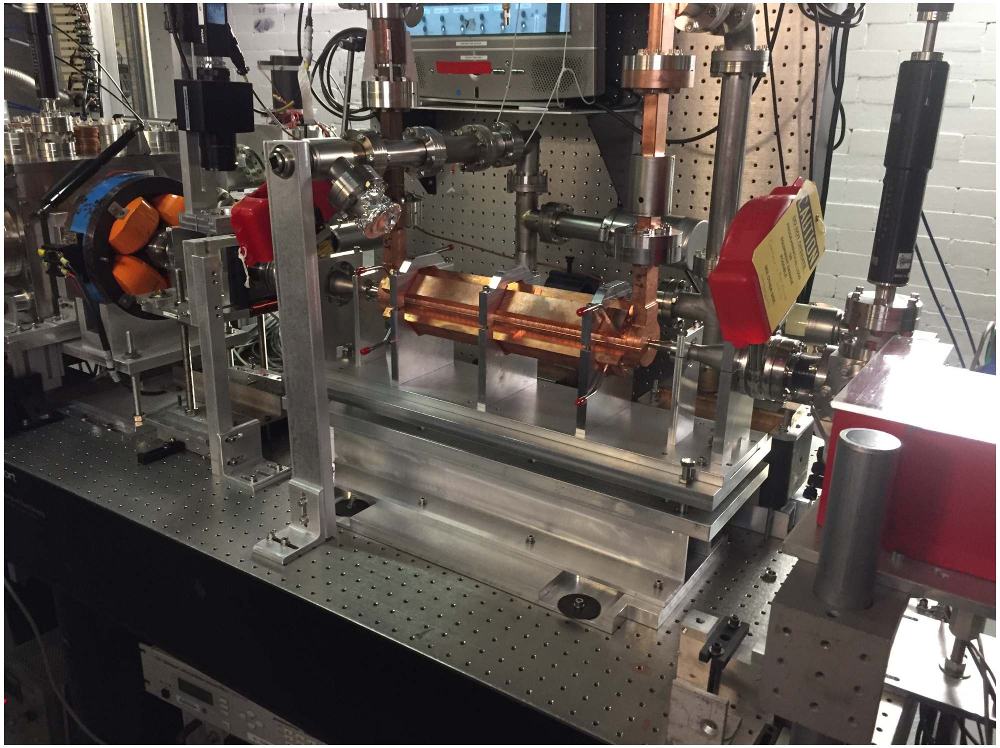
- March-April 30m waveguide and cavity were conditioned to 8 MW power
- In August power raised to 22 MW
- In September deflector with power window was installed on Beamline #2
- September-October deflector was reconditioned at beamline power increased to 30 MW

Deflector on beamline layout



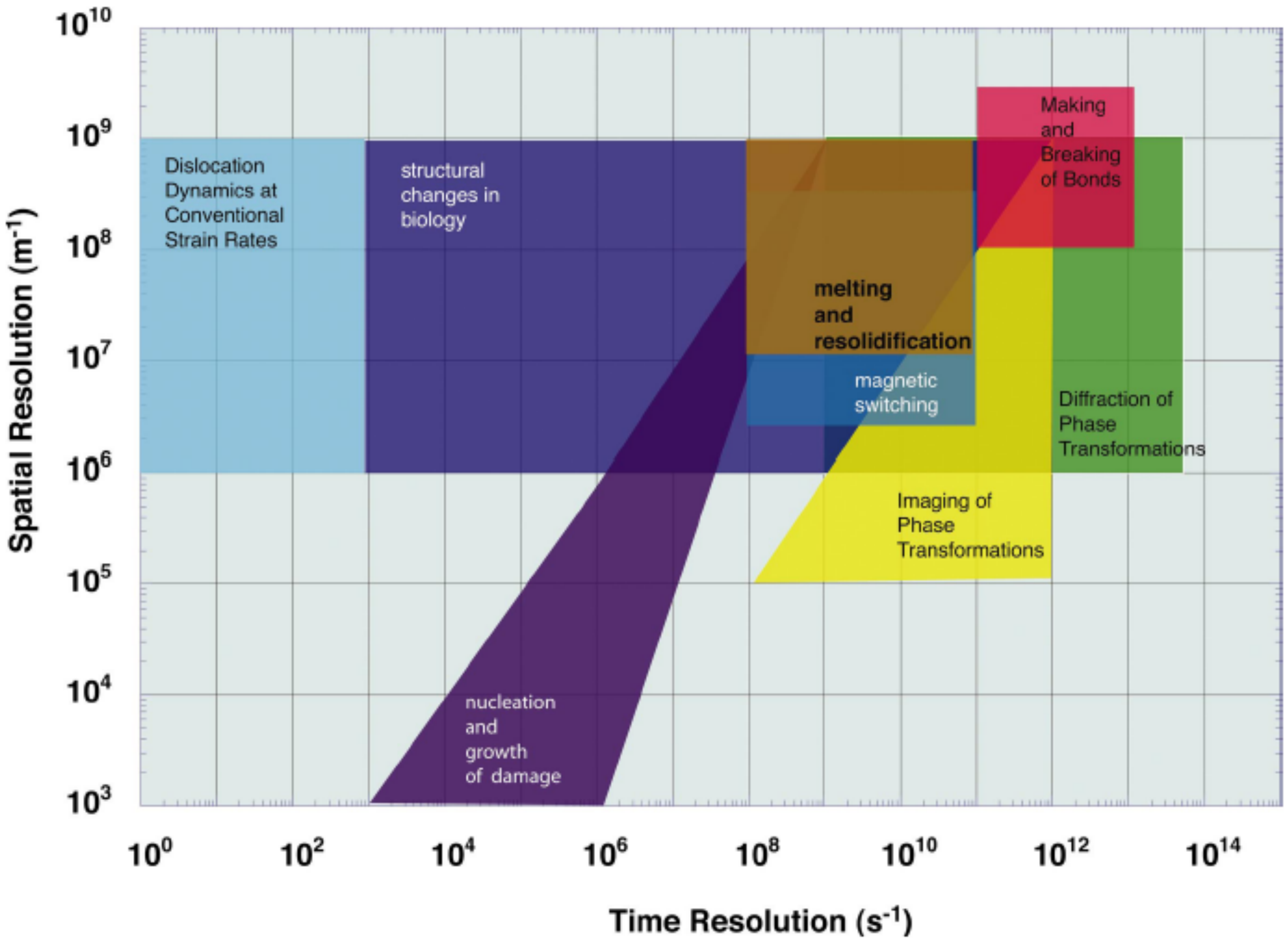


Conditioning is done.
20 MW of power is delivered



Back up slides

Structural changes in nature



W. E. King, *et al.*, J. Appl. Phys. 97, 111101 (2005)

By courtesy of Junjie Li

$La_{2-2x}Sr_{1+2x}Mn_2O_7$

Z. Sun, *et al.*, *PNAS* **108**, 11799 (2011)